U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-263 326

The Macroeconomic Impacts of Federal Pollution Control Programs

Chase Econometric Associates, Inc.

Prepared For
Environmental Protection Agency, Washington, D.C.

Jan 75

EPA-230/3-75-008

PB 263 326

The Macroeconomic Impacts of Federal Pollution Control Programs

by

Chase Econometric Associates, Inc.
Bala Cynwyd, Pennsylvania

undertaken for

The Council on Environmental Quality
The Environmental Protection Agency

January 1975

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-263 326

4. Title and Subtitle
The Macroeconomic Impacts of Federal Pollution Control Programs

5. Report Date
Jan 75

6.

7. Author(s)

8. Performing Organization Rept. No. EPA/230/3 75/008

9. Performing Organization Name and Address
Chase Econometric Associates, Inc.
Bala Cynwyd, Pennsylvania

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
Environmental Protection Agency
Washington, D. C.

13. Type of Report & Period Covered

14.

15. Supplementary Notes
Prepared in cooperation with Council on Environmental Quality, Washington, D.C. Portions of this document are not fully legible. (PC A02/MF A01)

16. Abstracts
This analysis of the macroeconomic impact of pollution control expenditures was sponsored by CEQ and EPA as part of a continuing effort to assess the impact of environmental programs on the economy. Further studies on this issue are expected to be released this year. The analysis is based upon CEQ/EPA estimates of "incremental abatement costs" associated with current Federal air and water pollution control legislation. The cost estimates are primarily based on the assumption that the deadlines and standards established in the Clean Air Act (as amended) and the Federal Water Pollution Control Act (as amended) will be achieved. They, therefore, show a significant peaking prior to 1978.

17. Key Words and Document Analysis. 17a. Descriptors
*Air pollution abatement,
*Water pollution abatement,
*Government policies,
*Economic impact,

National government,
Cost analysis,
Environmental surveys,
Cost estimates,
Economic surveys,
Evaluation,
Standards.

17b. Identifiers/Open-Ended Terms

Clean Air Act,
Federal Water Pollution Control Act Amendments of 1972.

17c. COSATI Field/Group 13 B 5 C

18. Availability Statement
National Technical Information Service
Springfield, Virginia 22161

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 21p

22. Price PC A02/MF A01

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

TABLE OF CONTENTS

Introduction	1
Principal Conclusions	1
Impact on Inflation	1
Impact on Economic Growth	2
Impact on Unemployment	2
Investment	2
Pollution Abatement Costs	3
Methodology and Assumptions	3
Operation of Model	7
Results of Analysis	9
Impact on Prices	9
Impact on Economic Growth	9
Impact on Investment	13
Impact on Foreign Trade	13
Other Economic Impacts	13
Sensitivity Analyses	14
Conclusion	16

FOREWORD

This analysis of the macroeconomic impact of pollution control expenditures was sponsored by CEQ and EPA as part of a continuing effort to assess the impact of environmental programs on the economy. Further studies on this issue are expected to be released this year.

The analysis is based upon CEQ/EPA estimates of "incremental abatement costs" associated with current Federal air and water pollution control legislation. These costs are defined as the public and private expenditures expected to be made as a result of Federal environmental legislation which would not have been made in the absence of this legislation. The methodology and data sources used in estimating these costs are described in the fifth annual report of the CEQ.*

The cost estimates are primarily based on the assumption that the deadlines and standards established in the Clean Air Act (as amended) and the Federal Water Pollution Control Act (as amended) will be achieved. They, therefore, show a significant peaking prior to 1978. There is some evidence that these deadlines will not all be met, and that some expenditures will be delayed beyond 1978. In this case the macroeconomic effects of the programs would likely be less than projected in these analyses.

However, the cost estimates do not fully include the costs associated with meeting the 1983 standards established by the 1972 amendments to the Federal Water Pollution Control Act, and therefore, the actual macroeconomic impacts at the end of the decade 1973-82 may be greater than projected. It should also be noted that the initial computer runs for this study were made in the fall of 1974 and hence some of the baseline forecasts do not completely reflect subsequent changes in economic conditions.

Further macroeconomic analyses of this type are expected to be undertaken in the future as the abatement cost estimates are changed.

Edwin H. Clark, CEQ
Roy N. Gamse, EPA
January 1975

*The Council on Environmental Quality, Environmental Quality - 1974 (U.S. Government Printing Office, 1974), Appendix 1 to Chapter 2.

Chase Econometrics

INTRODUCTION

This study represents an updating and continuation of the work done in previous years by Chase Econometrics for the Environmental Protection Agency (EPA) and the Council on Environmental Quality (CEQ) in assessing the macroeconomic impact of Federal environmental programs.[1] The analysis uses abatement cost estimates for the period 1973-1982 supplied by EPA and CEQ for air and water pollution abatement; these figures are given in Table 1. The estimates include capital investment, annualized capital costs, and operating and maintenance costs for each of the years in the period of analysis, and are disaggregated by two-digit industry. The cost estimates are consistent with the "incremental abatement costs" estimates published in the CEQ 1974 annual report.

The analysis was performed using the Chase Econometrics macroeconomic and input/output models, which are linked together into a single solution algorithm. The Chase model system thus allows analysis of both the impacts that different industries have on one another and on the interaction between pollution control expenditures and general economic factors such as the rate of growth, inflation, unemployment, and financial markets.

Most of the analysis is based upon the EPA/CEQ estimated level and timing of costs superimposed on a general cyclical economic scenario taken from a recent Chase Econometrics ten-year forecast. The impacts of the pollution control expenditures are estimated by comparing the economic forecasts including these expenditures with a forecast which is similar in every respect except that it excludes such additional environmental expenditures. It should be noted, however, that the inclusion of these expenditures involves several sets of adjustments to the model, which are discussed in greater detail in the Methodology and Assumptions section. However, an additional 11 simulations were also calculated using different cost estimates, alternative assumptions about the underlying economic scenario, the level of expenditures, and their timing over the ten-year period. These alternative scenarios are discussed in more detail later in this report.

PRINCIPAL CONCLUSIONS

Impact on Inflation

By 1978, when the bulk of the incremental investment in the industrial sector is complete, the wholesale price index will be 3.0% higher, the implicit GNP deflator will be 1.9% higher, and the consumer price index will be 1.2% higher than would have been the case in the absence of pollution control expenditures. These correspond to an average annual rate of increase of 0.6% for the WPI, 0.4% for the GNP deflator, and 0.24% for the CPI over this period.

---

[1] The Economic Impacts of Meeting Exhaust Emission Standards, 1971-1980, October, 1971; The Economic Impact of Pollution Control Upon the General Economy, October, 1972; The Economic Impact of Pollution Control: Macroeconomic and Industry Reports, July, 1973.

Chase Econometrics

In the latter half of the 1973-1982 decade the effect on prices is reduced. By 1982 the cumulative price differentials are only 2.4%, 0.9%, and 0.2%. This reduction in the price differentials results from a substantial reduction in investment and, in part, to the incremental slowdown in the economy. Thus, when averaged over the decade, the WPI increases 0.2% more, the GNP deflator 0.1% more, and the CPI 0.02% more with pollution control expenditures.

The largest single-year increments occur in 1976, when the WPI rises 1.8% more and the GNP deflator 0.9% more because of pollution control expenditures. For the CPI, the largest single-year differential is in 1977, when it rises 0.6% more than it otherwise would have.

Impact on Economic Growth

The stimulus of increased expenditures on pollution control growth in the early years of the decade is projected to raise the rate of economic growth above what it would have otherwise been through 1976. The maximum differential in the rate of growth occurs in 1975, when constant dollar GNP will be 1.6% higher with pollution control expenditures. In the latter half of the decade, however, low levels of pollution control investment combined with a higher rate of inflation leads to slower economic growth. By 1979 real GNP is projected to be 2.0% below the baseline forecast. This difference gradually diminishes and by 1982 the real GNP ends up virtually the same in both forecasts.

Impact on Unemployment

In keeping with the pattern of overall economic growth, the unemployment rate is 0.4% lower in 1975 and 0.3% lower in 1976 than it otherwise would have been. However, it gradually rises to a level of 0.4% above the baseline forecast by 1979. The difference gradually decreases and returns almost to zero by 1982.

Investment

The cost estimates provided by EPA/CEQ show incremental pollution control investments amounting to approximately 5% of total plant and equipment expenditures through 1976. This investment is estimated to result in somewhat lower levels of other types of investment, the substitution taking place approximately at a rate of $0.40 reduction in all other private investment for every $1.00 of investment in pollution control plant and equipment.[2] However, the housing sector usually accounts for the majority of the reduced investment because of its greater sensitivity to the cost and availability of borrowed funds. This impact depends very much on the particular fiscal and monetary policy being pursued by the government. The combined effects of slower economic growth, greater credit stringency, and the increased cost of capital reduce annual investment in plant and equipment some 4.8% below the baseline level in 1979; this difference declines to 2.5% by 1982. Housing starts decline by as much as 15.3% in 1978, although this difference disappears by the end of the forecast period.

---

[2]This result is based on a number of simulations performed with the Chase Econometrics macro model under different assumptions about underlying economic conditions.

Chase Econometrics

POLLUTION ABATEMENT COSTS

The cost estimates used in this analysis are consistent with the most recent CEQ estimates of "incremental abatement costs" being published in its 1974 annual report. The CEQ defines "incremental" abatement costs as expenditures made to satisfy the requirements of Federal environmental legislation beyond what would have been spent for pollution control in the absence of this legislation. Some industries are shown to have negative investment for air pollution in the years following 1978, which means that the firms in those industries would have undertaken certain investment for pollution control in any case, but did so sooner because of Federal legislation.

The cost estimates, which are predominantly based upon cost estimates provided in the 1974 edition of The Cost of Clean Air and the 1973 edition of The Economics of Clean Water, are summarized in Table I. Those figures were made available to Chase Econometrics for 15 two-digit industries in the manufacturing sector, utilities, and public sector investment. Very small expenditures which were also given for agriculture and mining were combined into the appropriate manufacturing category. These figures were given on an annual basis for the years 1973 to 1982 and were separated into expenditures for air pollution and water pollution abatement. The estimates included investment cost, annual operation and maintenance costs, and total annual costs. Annual costs include depreciation, interest charges, and operating and maintenance expenditures. In addition, figures were supplied for the cost of meeting mobile source emission standards for automobiles.

In addition to the basic analysis using the cost estimates summarized in Table 1, four other sensitivity analyses were run using different assumptions about the level or timing of costs. The first of these assumed that, on the average, capital investment would be 20% less than estimated, but that operating and maintenance costs would be 15% higher. This adjustment was made to reflect the impact of an increased emphasis on process changes rather than end-of-the-pipe treatment for pollution abatement. The EPA/CEQ cost estimates (predominantly) assume "end-of-the-pipe" treatment.

The second cost sensitivity scenario assumed that all costs were increased by 25% in order to estimate the likely macroeconomic impact if the EPA/CEQ estimates were significantly understated. The third cost sensitivity scenario involved an "evening out" of costs over the ten-year period -- and a delay of some costs beyond the period -- in order to determine the impact of a delay in implementing the current compliance dates. Finally, because of the sharp drop in housing starts in some years, we returned the level of housing activity to its baseline level in order to determine what the effect of this policy might be when applied in conjunction with the pollution control expenditures.

METHODOLOGY AND ASSUMPTIONS

The baseline values for the overall economic scenario are taken from the Chase Econometrics long-term macroeconomic outlook. In this forecast we predict a continuation of the recession throughout 1974 and a rise in the rate of unemployment continuing into 1975. After that, the economy gradually returns to a 4½% rate of unemployment in 1978 and remains at that level through 1980. This baseline projects another small business cycle from 1980 to 1983, but the unemployment rate returns to 4½% by 1983. The indicated growth rate for real GNP

TABLE I

ESTIMATED INCREMENTAL POLLUTION CONTROL EXPENDITURES, 1973-1982

	Air Pollution Abatement Costs 1973-77		Water Pollution Abatement Costs 1973-77		Air Pollution Abatement Costs 1978-82		Water Pollution Abatement Costs 1978-82	
	Investment	Annual	Investment	Annual	Investment	Annual	Investment	Annual
Food & Kindred Products [a]	1188	577	1448	1665	-56	504	119	2483
Textiles	0	0	417	486	0	0	34	726
Lumber	0	0	545	964	0	0	45	1466
Paper & Paper Products	130	195	974	760	-6	227	80	1105
Chemicals	285	306	1340	860	-14	338	110	1228
Petroleum [b]	565	560	966	702	-27	611	79	1014
Rubber & Misc. Plastic Products	0	0	214	399	0	0	18	608
Leather	0	0	126	143	0	0	10	214
Stone, Clay & Glass	195	290	616	231	-9	336	51	305
Iron & Steel	2479	1424	749	257	-118	1338	61	321
Primary Nonferrous Metals	946	1237	286	224	-45	1412	24	340
Fabricated Metals	0	0	482	253	0	0	40	352
Nonelectrical Machinery	0	0	376	210	0	0	31	295
Electrical Machinery	0	0	306	145	0	0	25	200
Transportation Equipment	0	0	238	103	0	0	20	140
Total Industrial	5786	4589	9083	7402	-275	4766	747	10797
Utilicies [c]	8861	10575	1925	754	1867	17440	2476	2319
Public	1314	1701	17900	7990	407	2702	-3150	10868
Total Fixed Source	15963	16865	28908	16146	1999	24908	73	23984
Mobile Source emission controls	10900	21150			20370	53280		

[a] includes feedlots and grain handling

[b] includes coal cleaning and natural gas production

[c] includes residential/commercial/industrial heating

All figures are in millions of 1973 dollars.

The definitions of investment and annual costs are given on page 3.

Chase Econometrics

averages 4.0% for the period 1975-1980 and 3.7% for the period 1981-1983. The rate of inflation as measured by the consumer price index averages 6.5% from 1975 to 1980 and 5.2% from 1981 to 1983.

Other major factors of the baseline forecast include the assumption that both the Federal and state and local government budgets will remain approximately in balance over the coming decade, with an average annual surplus of $3 billion over this period. The personal savings rate will average approximately 7½% for the period, representing an increase from the postwar average of 6½%; this will be due primarily to a higher average rate of inflation. New car sales will increase from a low level of 9.1 million units in 1974 to 11.2 million in 1976 and then rise slowly from that point to 12.8 million units in 1983. Housing starts will rebound from a low level of 1.4 million units this year to 1.9 million units in 1976 and will remain at approximately this level for the rest of the decade, but will not surpass the figure of 2.05 million starts recorded in 1973. Short-term interest rates will decline from present peak levels, but long-term interest rates will continue to rise and will average approximately 11% over the decade.

An alternative scenario, called the "full employment baseline" is not vastly different from the cyclical baseline. The EPA/CEQ provided guidelines to Chase Econometrics which stated that the real growth rate should average 4.6% per year for the 1975-80 period and 3.2% per year for the 1981-83 period. Furthermore, it was stipulated that the unemployment rate should average 5.4% in 1975 and 3.9% in both 1980 and 1983. We have maintained these conventions in solving for the baseline full employment scenario. As we move to higher rates of employment, the rate of price increase is slightly larger. Thus the consumer price index increases at a 6.7% annual rate during the forecast period, compared to a 6.0% increase in the baseline forecast. Similarly, the implicit GNP deflator rises at 6.5% instead of 5.8%, and the wholesale price index rises at 5.8% instead of 5.0%. The model has been adjusted so that real GNP rises at an average rate of 4.1% compared to 3.9% in the cyclical baseline case. Other variables are not significantly affected; the personal savings rate remains around 7½% and housing starts average just under 2 million units per year, although new passenger car sales rise about 1% a year faster.

We now consider the major steps which were taken to enter the EPA pollution cost figures into the Chase Econometrics industry and macro models. These can be briefly summarized as follows:

1) Enter the estimated investment costs for each industry into the model as an addition to the year by year demand for plant and equipment investment. These adjustments have two effects: (a) they are added directly to the investment functions in the model (see (7) below), and (b) they increase the asset base on which firms must earn the normal rate of return, hence resulting in higher prices.

Chase Econometrics

2) Enter the annual operation and maintenance costs and interest costs on pollution control investments into the model as an increase in each industry's production costs.

3) Apply "markup" factors to the increase in production costs, including capital depreciation, interest charges, and operation and maintenance, to determine the increase in prices. The markup factors, which represent the proportion of increased costs passed along as higher prices, have already been calculated on an industry by industry basis in the Chase Econometrics industrial models. The markups in general range from 0.8 to 1.0. A markup factor of 1.0 indicates that the average firm in the industry will be able to just recover all the increased costs through product prices.

4) Calculate the effect which these price increases will have on all industries. The previous step calculated only the direct effect of pollution controls on prices; that is, the amount that the price of steel (e.g.) rises because the steel industry invests in pollution control plant and equipment. However, we must also consider the effects which an increase in steel will have on machinery, autos, and other steel-using industries. In other words, we must measure the indirect as well as the direct effects of the price increases in each industry.

5) Convert the price increases by final demand categories to price increases by aggregate demand categories. We use a reverse bridge matrix to go from the 40 categories of final demand to the aggregate demand components contained in the Chase Econometrics macro model.

6) Translate the price increases which come from the input-output table and the bridge matrix -- as given in (5) above -- into actual ex post price changes by using the markup factors at the macro level. Until this has been accomplished we do not yet know what changes in final product prices will be, since the cost increases may not be fully passed along. Thus we use the markup factors at the final demand level (consumption, investment, and exports) to determine what the price rise will be before taking into account interactive and dynamic factors. These markup factors range from 0.8 to 1.1.

7) Adjust for changes in fixed business investment due to pollution control expenditures. Since more investment will be needed, the constant terms in the investment functions should be raised accordingly. However, we adjust the rental cost of capital upward by the percentage of investment for pollution control because it will now take more investment to produce a given amount of output. Hence the required rate of return on investment for capacity expansion will have to increase to offset the zero financial return on the pollution control investments.

8) Labor productivity was adjusted downward through a decrease in capital stock to reflect the fact that the additional capital expenditures for pollution control do not increase output/manhour.

Chase Econometrics

9) The index of industrial production was increased to represent the manufacture of auto emission control devices.

10) The consumption of transportation services was increased because of higher operating and maintenance costs due to the catalytic converters and other pollution control devices.

11) Corporate profits were adjusted downward to take into account the added costs of pollution control. The existing profit functions would show an increase in profits if prices rose and unit labor costs, raw material prices, interest rates, output, and capacity utilization all stayed at the same level.

12) The amount of financing undertaken by the Federal government increased, reflecting higher government debt because of increased spending in the public sector, and the amount of bond financing was also increased by the amount necessary to keep the debt/equity ratio constant.

A final round of price and output changes were then obtained by solving the complete Chase macroeconomic model, taking into account the interactive and dynamic factors.

OPERATION OF MODEL

We now consider the interactive and dynamic features of the macroeconomic model. The additional plant and equipment expenditures for pollution control will reduce the amount of investment in the private sector undertaken for other purposes. Part of this effect has already been included by raising the value of the rental cost of capital term.[3] However, several other factors need to be taken into account. First, an increase in nominal investment will place greater pressure on the capital markets, thus increasing interest rates and lowering other investment. Second, the increased investment demand will cause an increase in the costs of construction materials, labor, and equipment which results in some decline in constant dollar investment for a given level of output and financial variables. Third, a significant substitution exists between residential and nonresidential construction. This substitution works through changes in three variables: credit availability, the cost of construction, and the availability of labor. Since housing is more sensitive than other construction to all three of these variables, it suffers the greatest decline when other sectors of investment increase. The average elasticity of substitution between pollution control expenditures and other fixed investment is approximately 0.4, as has already been mentioned. This value can reach even larger values during periods of overfull employment and stringent monetary policy, although it does not in these simulations.

---

[3] The rental cost of capital is defined as $\frac{P_K\ (r+\delta)\ (1-uz-k)}{P_W\ (1-u)}$ where

P_K = supply price of capital goods
r = cost of borrowed funds
δ = depreciation rate
u = marginal statuatory tax rate.
z = depreciation factor
k = investment tax credit rate
P_W = wholesale price index

Chase Econometrics

It should be mentioned that a higher rate of inflation leads to a slower rate of growth in the economy for a number of other reasons. The most important link: a rise in the rate of inflation increases the savings rate and hence reduces consumption. According to the permanent income hypothesis, the marginal propensity to consume is lower for variable incomes than it is for fixed incomes. Yet clearly inflation penalizes those on fixed incomes at the expense of those on variable incomes. During inflation the decline in consumption by those on fixed incomes is not nearly matched by the increase in consumption by those on variable incomes -- even if we assume that income changes are the same -- and thus the savings rate rises. This is one of the important endogenous relationships in the macro model, and works through the income distribution and relative price terms in the consumption function. In addition there is a relative decline in durable purchases which is not balanced by the slightly higher spending on services.

The other channels by which a rise in prices lowers real output are more straightforward and require only brief commentary. First, for a given nominal money supply, higher prices must lead to a lower real money supply and hence an increase in interest rates unless there has been a specific offsetting shift in the liquidity preference function; this leads to the effects on investment which have already been discussed. Second, an increase in domestic prices for a given level of foreign prices leads to a deterioration in the net foreign balance in constant prices, although if the sum of the price elasticities of exports and imports is less than unity, the balance in nominal terms may increase. Third, a government budget which is fixed in current dollars buys fewer goods and services and generates less employment if prices increase. If the government attempts to retain its real purchasing power, it can do so only by creating additional money, which will in turn raise prices, or by borrowing additional funds, which will raise interest rates. We have chosen to assume that this latter route is operative, as indicated in our earlier discussion of constant adjustments.

All of these linkages reinforce the result that a rise in costs and prices will reduce aggregate demand and raise unemployment. As soon as this happens, however, secondary effects which act in the opposite direction begin to surface. A rise in unemployment will result in a lower level of wage increases in following years. Thus unit labor costs and prices will not rise as much for a given increase in productivity. In addition, the lower level of capacity utilization leads to lower markup factors. When these events begin to increase in importance, the rate of price increase starts to diminish. The decline in real GNP and employment, which was originally caused by higher prices, also begins to slacken. As this continues, prices and real GNP tend to return toward the level which would have occurred if the additional costs had not been added. Under a fairly wide variety of assumptions it is likely that the economy will eventually return to the level of output and employment which would have occurred in the absence of expenditures for pollution control, although prices will remain somewhat higher because of a lower level of productivity.

RESULTS OF ANALYSIS

Impact on Prices

The economic effects of pollution control expenditures are found to be rather modest. By 1978 the implicit GNP deflator is only 1.9% above the baseline case, the wholesale price index is only 3.0%, and the consumer price index only 1.2% above their baselines. The biggest price effect occurs in 1976, when the GNP deflator with pollution control costs rises 0.9% more than in the baseline scenario, and in 1977, when it rises 0.6% more. The difference in all other years is much less. Similarly, the wholesale price index rises an additional 1.9% in 1976 because of pollution control expenditures. This is the largest annual increase for any of the macroeconomic price indicators.

The fact that some price increase does occur is no surprise, since it is assumed that pollution control expenditures do not increase output per unit of labor or capital. The increased aggregate demand caused by the pollution control expenditures with no compensating increase in aggregate production inevitably results in higher prices. The amount of inflation will depend upon how much "slack" there is in the economy. At "full employment", the price increases caused by the additional demand could be very significant, while a sluggish economy will result in less increase. Even with a sluggish economy, however, there will be some price increase as firms pass on higher production costs in the form of higher prices, and as resources are competed away from other sectors to the production and installation of pollution control equipment.

Impact on Economic Growth

There has been a considerable amount of disagreement about whether pollution control expenditures on balance increase or diminish the rate of real growth and employment. Some economists have argued that the additional expenditures associated with pollution control investment will result in a higher growth rate and hence a higher level of employment. Our results support this analysis for the period before 1977. However, they also reveal that pollution controls contribute to the negative effect of higher inflation on real growth after 1977. This latter effect works through several different channels, which have already been described in the previous section.

As a result, we have a somewhat variegated picture of an incremental pattern of real growth over the forecast period. During the early years -- 1974 through 1976 -- real GNP is higher than the baseline solution and hence unemployment is lower. However, in 1977 and succeeding years the picture is reversed. First, less new investment is being added in 1977 and subsequent years. Second, the additional price increases resulting from the environmental expenditures set in motion forces that lead to a slower rate of real growth causing real GNP to be lower and unemployment higher in the perturbed solution in the years 1977 through 1982. The greatest decrement in real growth is reached in 1979, when the perturbed real GNP is 2.0% below the baseline solution.

After 1979, countervailing forces come into place. The lower rate of growth leads to a higher rate of unemployment, which in turn leads to smaller increases in wage rates, unit labor costs and prices. In addition, a decline in capacity

TABLE II

	1974	1975	1976	1977	1978	1979	1980	1981	1982
Gross National Product, Current Dollars									
Baseline projection	1405.1	1557.9	1738.9	1931.2	2149.6	2354.0	2555.8	2762.7	3008.9
With pollution control costs	1413.8	1586.8	1779.1	1962.0	2157.7	2344.5	2550.7	2775.8	3030.9
% Difference	.62	1.86	2.31	1.59	.38	-.40	-.20	.47	.73
Gross National Product, 1973 Dollars									
Baseline projection	1279.5	1303.1	1364.0	1435.2	1514.0	1570.6	1619.1	1664.3	1726.2
With pollution control costs	1286.9	1323.4	1379.0	1432.5	1491.8	1539.3	1594.9	1654.7	1723.4
% Difference	.58	1.56	1.10	-.19	-1.47	-1.99	-1.49	-.58	-.16
Implicit GNP Deflator, 1973 = 100									
Baseline projection	109.8	119.5	127.5	134.5	141.9	149.8	157.8	166.0	174.3
With pollution control costs	109.8	119.9	129.0	136.9	144.6	152.3	159.9	167.7	175.8
% Difference	.00	.33	1.18	1.78	1.90	1.67	1.33	1.02	.86
Consumer Price Index, 1973 = 100									
Baseline projection	110.9	120.5	128.6	136.4	144.6	152.9	161.3	169.9	178.6
With pollution control costs	111.0	121.0	129.4	138.0	146.4	154.6	162.5	170.6	179.0
% Difference	.09	.41	.62	1.17	1.24	1.11	.74	.41	.22
Wholesale Price Index, 1973 = 100									
Baseline projection	121.0	135.5	142.2	148.7	155.8	162.7	169.1	175.2	181.5
With pollution control costs	121.1	136.8	146.2	153.5	160.5	167.0	173.2	179.4	185.8
% Difference	.08	.96	2.81	3.23	3.02	2.64	2.42	2.40	2.37
Unemployment Rate, Percent									
Baseline projection	5.2	5.5	5.3	4.8	4.4	4.4	4.5	4.7	4.6
With pollution control costs	5.1	5.1	5.0	4.8	4.6	4.8	4.8	4.8	4.7
% Difference	-1.92	-7.27	-5.66	.00	4.55	9.09	6.67	2.13	2.17
Fixed Investment in Producers Durable Equipment, 1973 Dollars									
Baseline projection	91.4	95.7	102.8	109.3	116.7	121.8	126.4	130.4	135.9
With pollution control costs	93.8	102.4	107.4	110.2	114.4	117.7	123.0	129.0	135.4
% Difference	2.63	7.00	4.47	.82	-1.97	-3.37	-2.69	-1.07	-.37

TABLE II (cont'd)

	1974	1975	1976	1977	1978	1979	1980	1981	1982
Fixed Investment in Nonresidential Structures, 1973 Dollars									
Baseline projection	50.0	51.1	52.7	55.5	57.5	58.3	60.1	63.8	68.1
With pollution control costs	52.6	57.7	58.8	58.3	55.9	53.8	55.1	59.6	63.5
% Difference	5.2	12.92	11.57	5.05	-2.78	-7.72	-8.32	-6.58	-6.75
Housing Starts, Millions of Units									
Baseline projection	1.60	1.90	1.88	1.93	2.03	2.00	1.91	1.82	1.88
With pollution control costs	1.55	1.79	1.66	1.64	1.72	1.82	1.87	1.86	1.92
% Difference	-3.13	-5.79	-11.70	-15.03	-15.27	-9.00	-2.09	2.20	2.13
Percentage Growth Rate of GNP, 1973 Dollars									
Baseline projection	-1.2	1.8	4.7	5.2	5.5	3.7	3.1	2.8	3.7
With pollution control costs	-.6	2.8	4.2	3.9	4.1	3.2	3.6	3.7	4.2
Difference	.6	1.0	-.5	-1.3	-1.4	-.5	.5	.9	.5
Percentage Growth Rate of CPI									
Baseline projection	10.9	8.7	6.8	6.0	6.0	5.8	5.5	5.3	5.1
With pollution control costs	11.0	9.0	7.2	6.4	6.1	5.6	5.1	5.0	4.9
Difference	.1	.3	.4	.4	.1	-.2	-.4	-.3	-.2
Trade Balance, 1973 Dollars									
Baseline projection	8.9	6.0	6.0	7.4	9.1	11.1	12.5	13.8	14.7
With pollution control costs	8.7	5.0	5.6	7.3	8.8	10.5	11.7	13.0	14.0
% Difference	-2.25	-16.67	-6.67	-1.35	-3.30	-5.41	-6.40	-5.80	-4.76
Consumption of Autos and Parts, 1973 Dollars									
Baseline projection	49.3	55.0	59.4	61.8	62.3	61.7	61.3	61.6	62.5
With pollution control costs	49.4	55.3	58.8	60.4	59.7	59.2	59.7	61.0	62.0
% Difference	.20	.55	-1.03	-2.27	-4.17	-4.05	-2.61	-.97	-.80
Consumption of Other Durables, 1973 Dollars									
Baseline projection	75.1	75.9	79.1	82.4	86.3	89.5	91.9	94.4	97.4
With pollution control costs	75.2	76.9	80.3	83.2	86.2	88.4	91.0	94.2	97.6
% Difference	.13	1.32	1.52	.97	-.12	-1.23	-.98	-.21	.21

TABLE II (cont'd)

	1974	1975	1976	1977	1978	1979	1980	1981	1982
Consumption of Nondurables, 1973 Dollars									
Baseline projection	333.7	337.3	354.2	370.7	385.7	397.8	408.7	419.5	432.0
With pollution control costs	334.4	340.1	357.7	372.7	384.8	394.8	405.9	418.4	432.1
% Difference	.21	.83	.99	.54	-.23	-.75	-.69	-.26	.02
Consumption of Services, 1973 Dollars									
Baseline projection	336.5	340.5	352.7	370.4	393.2	411.4	425.3	437.3	450.5
With pollution control costs	337.3	343.8	357.0	373.4	393.0	407.9	421.1	436.0	452.2
% Difference	.24	.97	1.22	.81	-.05	-.85	-.99	-.30	.38
Disposable Personal Income, Current Dollars									
Baseline projection	985.0	1089.4	1211.4	1345.8	1488.4	1629.7	1772.7	1920.8	2088.4
With pollution control costs	988.8	1104.2	1236.0	1370.3	1503.8	1633.0	1772.3	1925.1	2095.0
% Difference	.39	1.36	2.03	1.82	1.03	.20	-.02	.22	.32
Corporate Profits Before Taxes, Current Dollars									
Baseline projection	142.2	137.1	158.3	181.8	209.2	227.8	247.7	267.1	294.9
With pollution control costs	145.3	146.8	165.3	179.1	198.0	213.8	236.6	261.4	290.1
% Difference	2.18	7.08	4.42	1.49	-5.35	-6.15	-4.48	-2.13	-1.63
Corporate Profits After Taxes, Current Dollars									
Baseline projection	86.1	78.6	90.8	103.4	121.0	133.0	145.6	158.0	175.4
With pollution control costs	88.0	84.4	95.0	101.8	114.2	124.7	139.0	154.5	172.5
% Difference	2.21	7.38	4.63	-1.55	-5.62	-6.24	-4.53	-2.22	-1.65
Aa Corporate Bond Rate for New Issues									
Baseline projection	9.58	10.59	10.97	11.47	10.97	11.01	11.03	10.97	10.87
With pollution control costs	9.70	11.29	11.85	12.47	11.77	11.44	11.23	11.16	11.18
% Difference	1.25	6.61	8.02	8.72	7.29	3.91	1.81	1.73	2.85
Index of Industrial Production, 1973 = 100									
Baseline projection	100.3	103.6	109.7	115.2	120.9	124.6	127.9	131.0	135.6
With pollution control costs	101.2	106.1	111.7	115.6	119.4	122.1	126.1	130.5	135.6
% Difference	.90	2.41	1.82	.35	-1.24	-2.01	-1.41	-.38	.00

Chase Econometrics

utilization reduces the size of markups in several industries. Thus for the 1980-82 period the shortfall in real GNP averages only 0.7%, and in 1982 the perturbed real GNP has virtually returned to the baseline level.

Impact on Investment

Turning to the major components of investment, we find that constant dollar purchases of producers durable goods are up 7.0% in 1975, but most of this increase represents investment in pollution control equipment. Thereafter, there is a relative reduction in pollution control expenditures, and the difference declines to 0.8% in 1977 and -3.3% in 1979 before returning almost to zero. Nonresidential construction increases 13% in 1975 and 5% in 1977, but reaches a maximum negative decrement of -8.3% in 1980. These decrements are due entirely to higher costs and a lower level of economic activity, since incremental pollution control investment in total remains positive throughout the decade.

Housing starts are hard hit and decline by 5.8% in 1975, 11.7% in 1976, and 15% in both 1977 and 1978. After that the difference narrows and they are only 9% below the baseline solution by 1982. The impact on housing, of course, depends very much on the particular monetary and fiscal policies being pursued by the Federal government. The government, for instance, could take steps directly to aid the housing market. To determine the impact of such a policy on prices and GNP growth, we calculated additional simulation exercises in which we returned housing to its baseline level. We found that stimulating the housing industry simply resulted in reducing the amount of funds available to the remaining borrowing sectors, particularly fixed business investment, and hence had relatively little short-run effect on the overall macroeconomic picture.

Impact on Foreign Trade

The foreign trade balance in 1973 dollars declines slightly in all years of the simulation period, unlike other components of income and production which start with positive increments but then become negative around 1978. The major cause of this is the increased level of prices over the entire period. This factor is offset in part by fluctuations in economic activity. Hence in 1975, when both prices and domestic output are higher, the decrement is largest; higher prices reduce U. S. competitiveness in international markets, while higher output increases U. S. imports. In later years the factors work in opposite directions. Prices are still higher, but a lower level of output reduces the demand for imports. On balance, however, the price effects always outweigh the income effects.

Other Economic Impacts

The major components of consumption follow the pattern which might be expected. All sectors show an increase in 1974 and 1975 and a decrease for the period 1978-1981. Auto sales are relatively harder hit because of the mobile source emission controls and decline by a peak amount of 4.2% in 1978; this corresponds to about 500,000 cars.[4] They also remain below the baseline solution in 1982 when all other major components of consumption show slight positive increments. The change in auto sales is due to a combination of factors which include changes in relative

[4]The cost estimates underlying this analysis were based on the April 1973 implementation schedule announced by the administrator of EPA in April 1973 and therefore do not take account of subsequent modifications of this schedule which will reduce these costs.

Chase Econometrics

prices, disposable income, the rate of unemployment, and credit conditions. Gasoline prices are explicitly included but other operations and maintenance costs are not included in the new car equation.

Disposable personal income (DPI) in current dollars is slightly above the baseline solution in all years except 1980. In constant dollars, it follows the general pattern of other economic variables; it is higher through 1977, lower for 1978 through 1981, and slightly positive in 1982. The actual changes in constant dollars can be calculated by subtracting the percentage changes in the CPI from the percentage changes in DPI. Corporate profits fluctuate much more on both a pretax and after-tax basis. They rise 7% higher in 1975 and 4½% higher in 1976 but then decline sharply to a maximum decrement of 6% in 1979. After 1979, as with other macroeconomic variables, the difference between the perturbed and the baseline solution return toward zero, the difference being only 1.6% in 1982. No measure for "constant dollar" corporate profits is given, since this term is not easily defined.

In the financial markets, the Aa corporate bond rate for new issues is above the baseline solution throughout the simulation period. It is higher by 0.7% (or a 6.6% increase) in 1975; the difference continues to widen to 1977, where the gap is a full 100 basis points (or an 8.7% increase). After that it diminishes somewhat but still remains 0.3% higher (or a 2.9% increase) by 1982. Finally, the index of industrial production follows much the same pattern as constant-dollar GNP, with the peak positive difference of 2.4% being recorded in 1975 and the peak negative difference of 2.0% occurring in 1979. The projected levels and differences in interest rates depend, of course, upon monetary policy.

Sensitivity Analyses

We now consider the results of alternative simulation analyses which tested changes in the underlying assumptions about the condition of the economy or about the level or timing of pollution abatement expenditures. First, we summarize the changes that occur when we superimpose the expected levels of pollution control costs on the "full employment" baseline. As would be expected under this scenario, the price increases are slightly larger although the differences are modest. For example, by 1982 we find that the wholesale price index has increased by about three-fifths, the implicit GNP deflator by about two-fifths, and the CPI by about one-fifth more than with the Chase cyclical economic scenario used in the earlier analyses. The declines in real GNP are also similar in nature although the timing pattern is somewhat different. The increase in producers durable equipment and nonresidential construction and the decline in housing starts all follow the same pattern.

The impacts under the "cyclical" and "full employment" cases are similar primarily because there is relatively little difference between the two economic scenarios. In particular, the cyclical scenario assumes that the unemployment rate averages approximately 4.5% whereas in the full employment scenario this rate moves from 4½% to 3.9% in 1980 and remains at that level. It is clear that somewhat greater differences would have been observed if we had run a true recession scenario with the unemployment rate as high as 6%. However, the alternative runs at full employment do indicate that the rise in prices, while somewhat greater, is not of major importance, although the difference is more significant for the WPI than for the CPI or GNP deflator.

For the second sensitivity analysis, the assumed abatement costs were adjusted by reducing investment costs by 10% and increasing O&M costs by an average of 15%. The purpose of this scenario was to test the impacts of increased emphasis upon process change rather than end-of-the-pipe treatment as an abatement strategy. This scenario (with the Chase cyclical economic base case) shows price rises about one-fourth less than in the original analysis. Because prices rise less, the maximum decrement in real GNP which occurs in 1979 is less than two-thirds as great as in the original analysis. By 1982 the change in consumer prices is only one-tenth less, but for the GNP deflator it is one-fifth less, and the wholesale price index one-third less. The housing market declines by only two-thirds as much and the other disturbances to the baseline growth pattern are similarly restrained.

The third sensitivity analysis involved increasing all costs by 25% in order to test the impacts which could be expected in case the EPA/CEQ estimates were seriously understated. This analysis showed the wholesale price index rising over one-fourth more by 1982 than the standard case, and the implicit GNP deflator by one-sixth, but the CPI by less than one-twelfth. These appear to be paradoxical results in that the increase in prices is smaller than the additional increase in expenditures. However, this is because the economy, and therefore the Chase macroeconomic model, contain many nonlinear and dynamic effects. These nonlinearities are evident in the changes in prices and output for earlier years. For example, in 1975 the incremental change in the wholesale price index is two-fifths above the standard, and in 1976 the difference is about one-third. These larger than proportional price increases lead to a sharper than proportional decline in real output. For example, the decline in GNP in 1977 is over twice as large, and in 1978 it is two-thirds larger. Thus the higher than proportional price increases lead, as might well be expected, to higher than proportional declines in real production and increases in unemployment; thus increases in wage rates in future years are lower than the standard analysis, hence eventually leading to some mitigating factors affecting prices.

In the fourth sensitivity analysis the timing pattern of expenditures was evened out and in some cases extended beyond 1982 in order to test the impacts of extending implementation deadlines. As expected, phasing in the expenditures more evenly until 1982 does reduce the overall rate of price increase. In 1982, the WPI is one-third lower, the implicit GNP deflator is one-fifth lower than in the standard run, while the small increment in the CPI is not affected. The maximum decrement in GNP, which also occurs in 1979, is only about half as large, while the increase in the unemployment rate is only half as great. The decline in housing starts and in producers durable equipment purchases and nonresidential construction expenditures is only about half as much. Thus timing patterns are quite important; stretching out the expenditures reduces the effect on output and prices by almost half.

It could be argued that the very substantial decline in housing is not indicative of what would actually happen in the economy, since the government could take steps to aid the housing market. Thus in our last sensitivity analysis, we tested this possibility by returning housing to its baseline level in order to determine whether the effect in real growth and prices would be substantially different. However, we found that this was not the case. Adding funds to the housing market through action by the Federal government and its agencies simply resulted in reducing the amount of funds available to the capital goods sector and hence had relatively little effect on the overall macroeconomic picture.

Chase Econometrics

CONCLUSION

The figures supplied by EPA/CEQ on pollution control expenditures for the period 1973 to 1982 will have a noticeable but modest effect on the overall economy. During this ten-year period, prices will average approximately 0.2% a year higher than they would have in the absence of these expenditures, although in the early part of that period (1974-1977) the CPI increases an average of 0.3% more, the implicit GNP deflator increases an average of 0.4% more, and the WPI increases an average of 0.8% more per year. The maximum difference of 1.9% for prices is reached in 1976. These higher prices eventually result in a somewhat lower growth rate of GNP, with the maximum decrement of 2% reached in 1979, which in turn results in a rate of unemployment which is 0.4% higher. However, the differences gradually diminish so that by 1982 real growth and employment are at virtually the same levels which would have occurred in the absence of pollution control investment, while prices are only some 2% higher.

We also experimented with various alternative assumptions concerning the underlying economic scenario and the level and timing of expenditures. The increase in prices would be about two-fifths higher if the economy were operating at full employment throughout this period; however, this does not appear to be a near-term problem. An increase in expenditures of 25% would raise the incremental change in prices about two-fifths in the peak years and would also have a greater negative effect on real growth and employment. Finally, a stretching out of expenditures to level peak year purchases would reduce the economic effects on output and prices by as much as one-half.

* * * *